CLAIMS

What is claimed is:

1. An optical transmitter suitable for use in connection with an optical communications system that includes an optical fiber transmission medium, the optical transmitter comprising:

a substrate; and

a surface emitting laser attached to the substrate and configured for optical communication with the optical fiber, the surface emitting laser comprising:

a first semiconductor layer of a first doping type, wherein the first doping type is selected from a group consisting of n-type doping and p-type doping;

a second semiconductor layer of a second doping type, wherein the second doping type is selected from a group consisting of n-type doping and p-type doping, and the second doping type is different from the first doping type;

an active region located between the first and second semiconductor layers;

a third semiconductor layer of the second doping type, wherein the second and third semiconductor layers are in direct contact with each other, and an interface between the second and third semiconductor layers is characterized by at least one of: lattice mismatch; and, trap-like defects;

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a concentration of dopants of the second doping type located in close proximity to the interface between the second and third semiconductor layers, wherein the concentration of dopants of the second doping type is in addition to bulk dopant concentrations in either the second semiconductor layer or the third semiconductor layer;

a top mirror layer; and

a bottom mirror layer, the bottom mirror layer cooperating with the top mirror layer and the active region to at least partially define a laser cavity.

2. The optical transmitter as recited in claim 1, wherein the laser cavity is configured to output laser light in a substantially vertical direction.

3. The optical transmitter as recited in claim 1, wherein the surface emitting laser comprises a monolithic optoelectronic semiconductor.

4. The optical transmitter as recited in claim 1, wherein the top mirror layer includes a top surface that is substantially square.

5. The optical transmitter as recited in claim 1, wherein the top mirror layer is attached to the third semiconductor layer.

6. The optical transmitter as recited in claim 1, wherein the bottom mirror layer is interposed between the substrate and the first semiconductor layer.

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7. The optical transmitter as recited in claim 1, wherein the surface emitting laser is configured to transmit optical radiation through at least one of: a top surface of the top mirror layer; and, the substrate.

8. The optical transmitter as recited in claim 1, wherein the surface emitting laser comprises a vertical cavity surface emitting laser.

9. The optical transmitter as recited in claim 1, wherein the concentration of dopants comprises a delta doping layer of the second doping type located in close proximity to the lattice mismatched interface.

10. The optical transmitter as recited in claim 1, wherein the second semiconductor layer comprises two sublayers with a contaminated interface therebetween.

11. The optical transmitter as recited in claim 1, wherein the first and second semiconductor layers comprise materials selected from a first materials system, and wherein the third semiconductor layer comprises materials selected from a second materials system, the first and second materials systems being lattice mismatched.

12. The optical transmitter as recited in claim 11, wherein at least one of the first and second materials systems is based on a semiconductor compound.

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13. The optical transmitter as recited in claim 12, wherein at least one of the materials systems is based on a III-V semiconductor compound.

14. The optical transmitter as recited in claim 12, wherein at least one of the materials is based on a II-VI semiconductor compound.

15. The optical transmitter as recited in claim 12, wherein at least one of the materials is based on silicon.

16. The optical transmitter as recited in claim 12, wherein the first materials system is based on InP compounds, and wherein the second materials system is based on a II-VI semiconductor compound.

17. The optical transmitter as recited in claim 1, wherein the concentration of dopants comprises a delta doping layer of the second doping type located in close proximity to the lattice mismatched interface.

18. The optical transmitter as recited in claim 17, wherein the delta doping layer lies substantially within the second semiconductor layer.

19. The optical transmitter as recited in claim 17, wherein the delta doping layer lies substantially within the third semiconductor layer.

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20. The optical transmitter as recited in claim 17, wherein the delta doping layer lies proximate the interface between the second semiconductor layer and the third semiconductor layer.

21. The optical transmitter as recited in claim 17, wherein the delta doping layer is located at a standing wave null of the laser cavity.

22. The optical transmitter as recited in claim 17, wherein the second semiconductor layer comprises two sublayers with a contaminated interface therebetween.

23. The optical transmitter as recited in claim 22, wherein the second semiconductor layer further comprises a second delta doping layer of the second dopant type located in close proximity to the contaminated interface.

24. The optical transmitter as recited in claim 22, wherein the contaminated interface is a result of native oxide on one of the two sublayers.

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25. The optical transmitter as recited in claim 22, wherein the third semiconductor layer is wafer bonded to the second semiconductor layer.

26. The optical transmitter as recited in claim 22, wherein the third semiconductor layer is metamorphically grown on the second semiconductor layer.

27. The optical transmitter as recited in claim 22, wherein the contaminated interface is located at a standing wave null of the laser cavity.

28. The optical transmitter as recited in claim 1, wherein the first doping type comprises n-type doping.

29. The optical transmitter as recited in claim 1, wherein laser light is the primary output of the optical transmitter.

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30. An optical amplification device suitable for use in connection with an optical communications system that includes an optical transmitter and an optical fiber transmission medium, the optical amplification device comprising:

a lasing semiconductor optical amplifier configured to receive an optical signal from the optical transmitter by way of the optical fiber, and comprising:

a first semiconductor layer of a first doping type, wherein the first doping type is selected from a group consisting of n-type doping and p-type doping;

a second semiconductor layer of a second doping type, wherein the second doping type is selected from a group consisting of n-type doping and p-type doping, and the second doping type is different from the first doping type, and the second semiconductor layer cooperating with the first semiconductor layer to at least partially define an amplifying path;

an active region located between the first and second semiconductor layers;

a third semiconductor layer of the second doping type, wherein the second and third semiconductor layers are in direct contact with each other and an interface between the second and third semiconductor layers is characterized by at least one of: lattice mismatch; and, trap-like defects;

a concentration of dopants of the second doping type located in close proximity to the interface between the second and third semiconductor layers, wherein the concentration of dopants of the

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second doping type is in addition to bulk dopant concentrations in either the second semiconductor layer or the third semiconductor layer;

a pump input to the active region;

a top mirror layer; and

a bottom mirror layer, the bottom mirror layer cooperating with the top mirror layer and the active region to at least partially define a laser cavity;

an optical input arranged for communication with the amplifying path and configured to receive the optical signal; and

an optical output arranged for communication with the amplifying path and configured to pass an amplified optical signal.

31. The optical amplification device as recited in claim 30, further comprising a substrate to which the lasing semiconductor optical amplifier is attached.

32. The optical amplification device as recited in claim 30, wherein the pump input comprises:

a p-type electrical contact in communication with at least a portion of the lasing semiconductor optical amplifier; and

a plurality of electrically isolated n-type electrical contacts in communication with the lasing semiconductor optical amplifier.

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33. The optical amplification device as recited in claim 30, wherein the lasing semiconductor optical amplifier comprises a monolithic optoelectronic semiconductor.

34. The optical amplification device as recited in claim 30, wherein the primary output of the optical transmitter is laser light for use as a ballast to amplify the optical signal.

35. The optical amplification device as recited in claim 30, wherein the first and second semiconductor layers cooperate with each other to at least partially define at least one of: the optical input; and, the optical output.

36. The optical amplification device as recited in claim 30, wherein the top mirror layer includes a top surface that is substantially in the form of a rectangle having sides of unequal length.

37. The optical amplification device as recited in claim 30, wherein the laser cavity is oriented substantially vertically with respect to the amplifying path.

38. The optical amplification device as recited in claim 30, wherein the concentration of dopants comprises a delta doping layer of the second doping type located in close proximity to the lattice mismatched interface.

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39. The optical amplification device as recited in claim 30, wherein the first and second semiconductor layers comprise materials selected from a first materials system, and wherein the third semiconductor layer comprises materials selected from a second materials system, the first and second materials systems being lattice mismatched.

40. The optical amplification device as recited in claim 30, wherein the top mirror layer is attached to the third semiconductor layer.

41. The optical amplification device as recited in claim 30, wherein the bottom mirror layer is interposed between the substrate and the first semiconductor layer.

42. The optical amplification device as recited in claim 30, wherein the concentration of dopants comprises a delta doping layer of the second doping type located in close proximity to the lattice mismatched interface.

43. The optical amplification device as recited in claim 30, wherein the second semiconductor layer comprises two sublayers with a contaminated interface therebetween.

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44. The optical amplification device as recited in claim 30, wherein the pump input is configured and arranged to permit pumping of the active region above a lasing threshold for the laser cavity, a gain of the active region being clamped to a gain value which is substantially independent of an amplitude of the optical signal as the optical signal propagates along the amplifying path, the amplifying path being non-collinear with an optical path of the laser cavity, and the optical signal being amplified by the gain value as the optical signal propagates along the amplifying path.

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45. An optical transmitter suitable for use in connection with an optical communications system that includes an optical fiber transmission medium, the optical transmitter comprising:

a substrate; and

a vertical cavity surface emitting laser attached to the substrate and configured for optical communication with the optical fiber, the vertical cavity surface emitting laser taking the form of a monolithic semiconductor device and comprising:

a bottom cladding layer comprising n-doped InP;

a top cladding layer comprising p-doped InP;

an active region located between the bottom and top cladding layers and selected from the group consisting of: double heterostructure of p-InAlAs/I- InAlGaAs/n-InAlAs; multiple quantum well; and, single quantum well;

a confinement layer in direct contact with the top cladding layer and comprising p-GaAs/AlGaAs, and an interface between the top cladding layer and the confinement layer being characterized by at least one of: lattice mismatch; and, trap-like defects;

a concentration of n-type dopants located in close proximity to the interface between the top cladding layer and the confinement layer, wherein the concentration of the n-type dopants is in addition to bulk dopant concentrations in either the top cladding layer or the confinement layer;

a top hybrid mirror; and

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a bottom Bragg reflector, the bottom Bragg reflector cooperating with the top hybrid mirror and the active region to at least partially define a laser cavity configured to output laser light in a substantially vertical direction.

46. The optical transmitter as recited in claim 45, wherein the concentration of dopants comprises a delta doping layer of n-type dopants located in close proximity to the interface between the top cladding layer and the confinement layer.

47. The optical transmitter as recited in claim 45, wherein the confinement layer includes a confinement structure that defines an aperture configured and arranged to pass a pump current.

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48. An optical amplification device suitable for use in connection with an optical communications system that includes an optical transmitter and an optical fiber transmission medium, the optical amplification device comprising:

a lasing semiconductor optical amplifier configured to receive an optical signal from the optical transmitter by way of the optical fiber, and comprising:

a bottom cladding layer comprising n-doped InP;

a top cladding layer comprising p-doped InP, the top cladding layer cooperating with the bottom cladding layer to at least partially define an amplifying path;

an active region located between the bottom and top cladding layers and selected from the group consisting of: double heterostructure of p-InAlAs/I- InAlGaAs/n-InAlAs; multiple quantum well; and, single quantum well;

a confinement layer in direct contact with the top cladding layer and comprising p-GaAs/AlGaAs, and an interface between the top cladding layer and the confinement layer being characterized by at least one of: lattice mismatch; and, trap-like defects;

a concentration of n-type dopants located in close proximity to the interface between the top cladding layer and the confinement layer, wherein the concentration of the n-type dopants is in addition to bulk dopant concentrations in either the top cladding layer or the confinement layer;

a pump input to the active region;

a top hybrid mirror; and

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a bottom Bragg reflector, the bottom Bragg reflector cooperating with the top hybrid mirror and the active region to at least partially define a laser cavity configured to output laser light in a substantially vertical direction;

an optical input arranged for communication with the amplifying path and configured to receive the optical signal; and

an optical output arranged for communication with the amplifying path and configured to pass an amplified optical signal.

49. The optical amplification device as recited in claim 48, wherein the concentration of dopants comprises a delta doping layer of n-type dopants located in close proximity to the interface between the top cladding layer and the confinement layer.

50. The optical amplification device as recited in claim 48, wherein the top and bottom cladding layers cooperate with each other to at least partially define the optical input and the optical output.

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